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ELECTRIC DISCHARGE SURFACE TREATMENT METHOD FOR GEARS

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(57) [Abstract]

[Issue]

An electric discharge surface treatment method for gears is provided, for which a production cost of a green compact electrode can be decreased, and the electrode can be commonly used for gears that have different numbers of teeth, and can be used without problems even if the electrode is wasted to some extent, so that a surface treatment cost can be substantially decreased, as well as position control for the workpiece with respect to the electrode can be easily performed, and a surface treatment can be performed only on engage starting sides of the gears.

[Means for solution]

In the method, in place of a female-die green compact electrode having a hollow portion with gear shape, a green compact electrode "E" formed in a rack shape is used, a gear "W" to be treated is rotated, and a hard coat is formed on a surface of teeth of the gear "W" by generating electric discharges between the gear "W" and the rack-shaped electrode "E" while relatively moving the two.

CLAIMS

What is claimed is:

1. An electric discharge surface treatment method for gears, which forms a hard coat, by generating an electric discharge between a gear to be treated and a green compact electrode, on a surface of the gear to be treated, wherein

the green compact electrode is formed in a rack-shaped, and the gear to be treated is rotated, and the hard coat is formed by generating the electric discharge between the gear and the rack-shaped electrode while relatively moving the two.

2. An electric discharge surface treatment method for gears, as recited in claim 1, wherein an engage starting side of the gear to be treated is approximated to the rack-shaped electrode, and the electric discharge is generated only on the engage starting side.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention is related to a surface property modifying technology for a gear, and particularly to an electric discharge surface treatment method, by which a pitting occurrence can be prevented by coating a hard coat on a surface of the gear, and a life extension of the gear can be achieved.

[0002]

[Description of the Related Art]

For example, regarding a continuous engaging gear of an automatic transmission, a pitting sometimes occurs particularly on a dedendum proximity portion of an engage starting side, and damage, originated from the pitting, of the gear is caused. In the past, a life extension of the gear has been achieved by coating a hard coat, such as a coat of "TiN" or "TiC", on a surface of the gear, in order to prevent a disruptive accident described above. The coating with the hard coat described above has been treated by, for example, the PVD (Physical Vapor Deposition) method using a vacuum furnace, or an electric discharge surface treatment method using an electric discharge machining device.

[0003]

In the electric discharge surface treatment method out of the methods, as illustrated in Fig. 3, a green compact electrode "Ec", formed in a female-die shape, having a gear shape hollow portion "H" of which dimension is slightly larger than the dimension of a gear "W" (workpiece) to be coating-treated by using, for example, "Ti" powder, is used as an electrode. Then, for example, in an electric discharge machining fluid such as white kerosene, pulse voltage is applied between the electrode "Ec" and the gear "W" to be treated while the electrode "Ec" is fluctuated, in a condition in which the gear "W" is installed in the hollow portion "H" of the electrode "Ec"; thereby electric discharges are generated between them. According to above processes, "TiC" is produced by reacting "Ti" in the electrode "Ec" with "C" being a constituent element of the electric discharge machining fluid, and a hard

coat is formed by depositing "TiC" on a surface of teeth of the gear "W".

[0004]

[Problems to be solved by the Invention]

However, in the electric discharge surface treatment method as described above, there have been problems in that a manufacturing cost of the electrode is expensive because a green compact electrode having a gear shape hollow portion is used, and process control is difficult because a gap between the electrode and a gear (workpiece) to be treated is determined according to a dimension of the electrode when manufactured, and electrode life is short because the gap is expanded according to exhaustion of the electrode, and many electrodes must be prepared according to the type of the workpiece because the same electrode cannot be used when the number of teeth of the gear to be treated is changed, so that the cost of the surface treatment is inevitably increased. Furthermore, there has been another problem in that a surface treatment performed only on an engage starting side of a gear, on which a pitting occurrence tendency is particularly remarkable, is difficult, so that it is a subject of the electric discharge surface treatment method for gears, as described above, to clear the above problems.

[0005]

[Object of the Invention]

The present invention has been made in focusing attention on the above problems of the conventional electric discharge surface treatment method

for gears. Then, it has been made in order to provide an electric discharge surface treatment method for gears, by which a production cost of a green compact electrode can be decreased, and the electrode can be used for gears that have different numbers of teeth, and can be used without problems even if the electrode is wasted to some extent, so that a gear surface treatment cost can be substantially decreased, as well as position control for the workpiece with respect to the electrode can be easily performed, and a surface treatment can be performed only on engage starting sides of the gears.

[0006]

[Means for solving the problems]

The electric discharge surface treatment method for gears, according to claim 1 of the present invention, forms a hard coat, by generating an electric discharge between a gear to be treated and a green compact electrode, on a surface of the gear to be treated, and is characterizing in that the method is processed in such a way that the green compact electrode is formed in a rack shape, and the gear to be treated is rotated, and the hard coat is formed by generating an electric discharge between the gear and the rack-shaped electrode while relatively moving the two, in an electric discharge surface treatment method for gears. Moreover, the electric discharge surface treatment method for gears, according to claim 2 of the present invention, is characterizing in that the method is processed in such a way that an engage starting side of the gear to be treated is approximated to the rack-shaped electrode, and the electric discharge is generated only on the engage

starting side. The above procedures of the electric discharge surface treatment method for gears are used for solving the conventional problems described above.

[0007]

[Action of the Invention]

In the electric discharge surface treatment method for gears, according to claim 1 of the present invention, because a green compact electrode formed in a rack shape is used in place of a female-die green compact electrode having a gear-shaped hollow portion, the electrode shape becomes simple, and the production cost of the green compact electrode is reduced to about one-tenth of the production cost of the gear-shaped female-die electrode. Moreover, because the gear to be treated is rotated and moved relatively on the rack-shaped green compact electrode, without installing the gear in the hollow portion of the female-die electrode, the same electrode can be commonly used as long as the module is not changed, even if the number of teeth of the gear to be treated is changed.

[0008]

Moreover, because a gap adjustment between the green compact electrode and the gear to be treated can be easily controlled, the electrode can be used further by controlling the distance between the electrode and the gear to be closer to each other, even if the electrode is wasted due to electric discharges; therefore, the useful life of the electrode can be increased.

[0009]

Furthermore, because position control for the gear with respect to the green compact electrode can be easily performed, as described in claim 2, a hard coat can be formed only on an engage starting side of the gear on which a pitting occurrence tendency is remarkable, by approximating an engage starting side of the gear to the rack-shaped electrode so as to generate the electric discharge only on the engage starting side; therefore, a pitting resistance of that side can be increased.

[0010]

Fig. 1 is an oblique perspective view in this case, for explaining a positional relation between the green compact electrode and the gear to be treated. As illustrated in Fig. 1 (a), an engage starting side of the gear "W" (workpiece) to be treated is approximated and engaged, in a noncontact condition, to the teeth of the rack-shaped green compact electrode "E" in an electric discharge machining fluid, and the electric discharge surface treatment is performed by generating electric discharges between the engage starting side of the gear "W" and the green compact electrode "E", while the gear "W" is rotated and the electrode "E" is moved. If the electrode "E" is wasted due to the electric discharges, a push treatment of pushing the electrode "E" in the radial direction of the gear "W" is performed, and the electric discharge surface treatment is continued while the distance between the two is controlled.

[0011]

Moreover, when the green compact electrode "E" is further wasted, by moving the electrode "E" in the axial direction of the gear "W" as illustrated

in Fig. 1 (b), the electric discharge surface treatment can be continued in the same manner. At this time, even if the engaging position is shifted in the axial direction, the front portion of the electrode "E" is wasted enough due to the previous electric discharges as illustrated in Fig. 1 (b), and the distance between the electrode "E" and the gear "W" is maintained to be more than a certain value, so that the electric discharge surface treatment is performed only on the engage starting side of the gear "W", and a hard coat is not formed on the front portion on which the coating is not needed.

[0012]

[Effects of the Invention]

The electric discharge surface treatment method for gears, according to claim 1 of the present invention, is performed in the above procedures. In other words, the method is performed in the procedures, in which a green compact electrode is formed in a rack shape, and the gear to be treated is rotated, and the hard coat is formed by generating electric discharges between the gear and the rack-shaped electrode, while relatively moving the two. In other words, because the rack-shaped green compact electrode is used, the production cost of a green compact electrode can be substantially reduced compared to the production cost of a conventional female-die electrode, as well as the number of types of the green compact electrode can be decreased, because the same electrode can be used for each of gears, even if the number of teeth of the gear is changed but the module is not changed. Therefore, a production cost and a management cost of the electrode can be reduced. Moreover, because the distance between the rack-shaped green

compact electrode and the gear to be treated can be easily controlled, even if the electrode is wasted due to the electric discharges, useful life of the electrode can be increased by controlling the distance between the electrode and the gear closer to each other. Therefore, an excellent effect of substantially reducing the cost of the electric discharge surface treatment for gears can be realized.

[0013]

In the electric discharge surface treatment method for gears, according to claim 2 of the present invention, the engage starting side of the gear to be treated is approximated to the rack-shaped electrode, and the electric discharges are generated only on the engage starting side. In other words, in the electric discharge surface treatment method for gears, according to the present invention, the electric discharges can be generated only on the engage starting side by approximating the gear to the rack-shaped electrode, because a rack-shaped green compact electrode is used and position control for the gear with respect to the electrode can be easily performed. Thereby, a hard coat can be formed only on the engage starting side of the gear on which a pitting easily occurs, and an excellent effect of substantially improving the pitting resistance on that portion can be realized.

[0014]

[Embodiment]

Hereinafter, the present invention will be more specifically explained

according to the following embodiment.

[0015]

By using "SCM420H" steel (chrome molybdenum steel) defined in JIS-G-4052, the steel was forged in a gear shape, and a final machining treatment was performed; then, a carburization quenching treatment was performed based on an ordinary method. A surface hardness of a gear "W" (workpiece) to be treated, which was formed as described above, was a Vickers hardness of about 850.

[0016]

Meanwhile, a rack-shaped green compact electrode "E", as illustrated in Fig. 1 (a), was formed by using "Ti" alloy powder, and, as illustrated in Fig. 1 (a), in an electric discharge machining fluid (white kerosene), only an engage starting side of the gear "W" to be treated, on which a carburization quenching treatment was performed, was engaged to the electrode "E" on a noncontact condition. Moreover, electric discharges were generated by applying pulse voltages between the electrode "E" and the gear "W", while the gear "W" was rotated and the electrode "E" was moved; thereby, a hard coat with "TiC" was formed on the engage starting side of the gear "W". In this case, a surface hardness on the coating portion of the gear "W" was a Vickers hardness of about 2500.

[0017]

A durability test of the gear "W", on which the electric discharge surface treatment was performed as described above, was performed, after the gear was installed in an actual automatic transmission, and the pitting life of the gear "W" was investigated. Then, the pitting life of the gear "W" was

compared with the pitting life of another gear as a comparison example, on which a surface treatment with a hard coat was not performed and only the carburization quenching treatment was performed.

[0018]

The result of the test is illustrated in Fig. 2, and it is recognized that the pitting life of the gear as a present invention example, on which an electric discharge surface treatment is performed by using "TiC", is substantially improved in comparison with the gear as a comparison example, on which only the carburization quenching treatment is performed.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 (a) is an oblique perspective view for explaining a procedure in which a treatment with a hard coat is performed only on an engage starting side of a gear in an electric discharge surface treatment method for gears, according to the present invention;

Fig. 1 (b) is an oblique perspective view for explaining a surface treatment procedure after one side of the rack-shaped electrode illustrated in Fig. 1 (a) is wasted;

Fig. 2 is a graph in which the pitting life of a gear as an invention example, on which an electric discharge surface treatment according to the present invention is performed, is compared with the pitting life of a gear as a conventional example, on which an electric discharge surface treatment is not performed; and

Fig. 3 is an oblique perspective view illustrating a conventional electric discharge surface treatment method for gears.

[Description of the Symbols]

"E" is a green compact electrode; and "W" (workpiece) is a gear to be treated.

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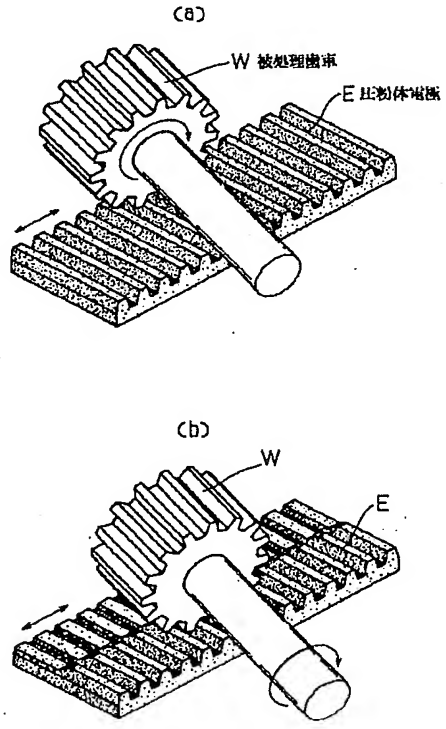
(54)【発明の名称】　歯車の放電表面処理方法

(57)【要約】
【課題】　圧粉体電極の製造コストが安価で、歯数の異なる歯車にも兼用することができ、しかも電極がある程度消耗しても問題なく使用することができ、表面処理コストの大幅な低減が可能であると共に、電極に対するワークの位置制御が容易で歯車の噛み合い始め側にのみ表面処理を施すことが可能な歯車の放電表面処理方法を提供する。
【解決手段】　歯車形状をなす空洞部を備えためす型圧粉体電極に代えて、ラック形状に成形した圧粉体電極Ｅを使用し、被処理歯車Ｗを回転させると共に、該歯車Ｗとラック状電極Ｅとを相対移動させながら両者の間で放電させて、被処理歯車Ｗの歯面に硬質被膜を形成させる。



【特許請求の範囲】
【請求項１】　被処理歯車と圧粉体電極との間に放電を発生させて被処理歯車の表面に硬質被膜を形成する歯車の放電表面処理において、
前記圧粉体電極をラック形状に成形し、被処理歯車を回転させると共に、該歯車と前記ラック状電極とを相対移動させながら両者の間に放電を発生させて硬質被膜を形成することを特徴とする歯車の放電表面処理方法。
【請求項２】　被処理歯車の噛み合い始め側をラック状電極に接近させて、噛み合い始め側にのみ放電させることを特徴とする請求項１記載の歯車の放電表面処理方法。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、歯車の表面改質技術に係わり、さらに詳しくは歯車の表面に硬質被膜をコーティングすることによってピッティングの発生を防止し、歯車寿命の延長を図ることができる放電表面処理方法に関するものである。
【０００２】
【従来の技術】例えば、オートマチックトランスミッションの常時噛み合い歯車などにおいては、特に噛み合い始め側の歯元近傍部にピッティングが発生し、これを起点に歯車が損傷することがあり、従来、このような破損事故を防止するため、歯形表面にＴｉＮやＴｉＣなどの硬質被膜をコーティングすることによって歯車の寿命延長を図るようにしている。このような硬質被膜のコーティングは、例えば真空炉を用いたＰＶＤ（Ｐｈｙｓｉｃａｌ　Ｖａｐｏｒ　Ｄｅｐｏｓｉｔｉｏｎ）法や、放電加工装置を用いた放電表面処理方法などによって行われていた。
【０００３】これらのうち、放電表面処理方法においては、図３に示すように、例えばＴｉ粉末を用いて、コーティング処理を施そうとする被処理歯車（ワーク）Ｗよりもわずかに大きい寸法の歯車形の空洞部Ｈを備えためす型に成形した圧粉体Ｅｃを電極として使用し、例えば白灯油などの放電液中において、圧粉体電極Ｅｃの空洞部Ｈ内に被処理歯車Ｗを挿入した状態で、電極Ｅｃを揺動させながら電極Ｅｃと歯車Ｗとの間にパルス電圧を印加してこれらの間に放電を発生させるようにしており、これによって電極Ｅｃ中のＴｉと放電液の構成元素であるＣとが反応してＴｉＣが生成され、被処理歯車Ｗの歯面上に堆積して硬質被膜が形成されるようになっていた。
【０００４】
【発明が解決しようとする課題】しかしながら、上記したような放電表面処理においては、歯車形状の空洞部を備えた圧粉体電極を使用するようにしているので、電極の製造コストが高いばかりでなく、電極の製造時の寸法によって電極と被処理歯車（ワーク）との隙間が決まってしまってコントロールが困難であり、電極の消耗の応じて隙間が拡がるため電極寿命が短く、さらに、被処理歯車の歯数が変わると同じ電極を使用することができないためにワークの種類ごとに電極を準備しておく必要があることなどから、表面処理コストの上昇を避けることができないという問題があった。また、ピッティングの発生傾向がとくに顕著な歯車の噛み合い始め側のみに表面処理を行うことが難しいという問題点があり、これらの問題点を解消することがこのような歯車の放電表面処理における課題となっていた。
【０００５】
【発明の目的】本発明は、従来の歯車の放電表面処理における上記課題に着目してなされたものであって、圧粉体電極の製造コストが低く、歯数の異なる歯車にも使用することができ、しかも電極がある程度消耗した状態でも問題なく使用することができ、歯車の表面処理コストの大幅な低減が可能であると共に、電極に対するワークの位置制御が容易で、歯車の噛み合い始め側にのみ表面処理を施すことも可能な歯車の放電表面処理方法を提供することを目的としている。
【０００６】
【課題を解決するための手段】本発明の請求項１に係わる歯車の放電表面処理方法は、被処理歯車と圧粉体電極との間に放電を発生させて被処理歯車の表面に硬質被膜を形成する歯車の放電表面処理において、前記圧粉体電極をラック形状に成形し、被処理歯車を回転させると共に、該歯車と前記ラック状電極とを相対移動させながら両者の間に放電を発生させて硬質被膜を形成する構成としたことを特徴とし、本発明の請求項２に係わる歯車の放電表面処理方法においては、被処理歯車の噛み合い始め側をラック状電極に接近させて、噛み合い始め側にのみ放電させる構成としたことを特徴としており、歯車の放電表面処理方法におけるこのような構成を前述した従来の課題を解決するための手段としている。
【０００７】
【発明の作用】本発明の請求項１に係わる歯車の放電表面処理方法においては、歯車形状の空洞部を備えためす型に成形した圧粉体電極の代わりに、ラック形状に成形した圧粉体電極を使用するようにしているので、電極形状が単純なものとなり、圧粉体電極の製造コストが歯車形状のめす型電極に較べて約１０分の１に削減される。また、被処理歯車をめす型電極の歯車形空洞部内に挿入することなく、ラック状の圧粉体電極上を回転させながら相対移動させるようにしているので、被処理歯車の歯数が変わったとしても、モジュールが同一でありさえすれば同じ電極が兼用されることになる。
【０００８】そして、圧粉体電極と被処理歯車との隙間の制御が容易なものとなるので、放電によって電極が消耗したとしても、電極との距離を詰めるようにコントロールすることによって、当該電極をさらに使用すること

ができるようになり、電極の耐用寿命が延びることになる。

【０００９】また、同様に圧粉体電極に対する被処理歯車の位置制御が容易なものとなるので、請求項２に記載しているように、被処理歯車の噛み合い始め側をラック状電極に接近させて、この噛み合い始め側にのみ放電させるようになすことによって、ピッティングの発生傾向が著しい歯車の噛み合い始め側のみに硬質被膜が形成されることになり、当該部分の耐ピッティング性が向上することになる。

【００１０】図１は、このときの圧粉体電極と被処理歯車の位置関係を説明する斜視図であって、図１（ａ）に示すように、放電液中においてラック状をなす圧粉体電極Ｅの歯形にワークである被処理歯車Ｗの噛み合い始め側を接近させて非接触で噛み合わせ、被処理歯車Ｗを回転させると共に電極Ｅを移動させながら、歯車Ｗの噛み合い始め側と圧粉体電極Ｅの間に放電を生じさせ表面処理を行う。放電によって電極Ｅが消耗してきたら、電極Ｅを歯車Ｗの径方向に追い込み処理を行い、両者の距離をコントロールして放電表面処理が続行される。

【００１１】そして、圧粉体電極Ｅがさらに消耗した時点で、図１（ｂ）に示すように、電極Ｅを歯車Ｗの軸方向に移動させることにより、同様の放電表面処理を続けることができる。このとき、噛み合い位置を軸方向にずらしたとしても、圧粉体電極Ｅの先端部分は、図１（ｂ）に示すように、それ以前の放電によって十分に消耗しており、被処理歯車Ｗとの距離が一定値以上に保持されるので、歯車Ｗの噛み合い始め側のみに放電表面処理が行われ、コーティングを必要としない先端側部分に硬質被膜が形成されることはない。

【００１２】

【発明の効果】本発明の請求項１に係わる歯車の放電表面処理方法は、上記構成、すなわち圧粉体電極をラック形状に成形し、被処理歯車を回転させると共に、該歯車と前記ラック状電極とを相対移動させながら両者の間に放電を発生させて硬質被膜を形成する構成としたものである。すなわち、ラック形状の圧粉体電極を使用するようにしていることから、歯車形状の空洞部を備えた従来のめす型電極に較べて、圧粉体電極の製造コストを大幅に削減することができると共に、被処理歯車の歯数が変わったとしてもモジュールが同一であれば、同じ電極を兼用することができるので、圧粉体電極の種類を減らすことができ、電極の製造コストおよび管理コストの削減が可能になる。さらに、ラック形状の圧粉体電極と被処理歯車との距離が容易に制御できるので、放電によって電極が消耗したとしても、電極との距離を詰めるようにコントロールすることによって、電極の使用期間を延ばすことができるようになり、歯車の放電表面処理コストの大幅な低減が達成できるという極めて優れた効果をもたらすものである。

【００１３】本発明の請求項２に係わる歯車の放電表面処理方法においては、被処理歯車の噛み合い始め側をラック状電極に接近させて、噛み合い始め側にのみ放電させるようにしている。すなわち、本発明に係わる歯車の放電表面処理方法においては、ラック形状の圧粉体電極を使用するようにしており、圧粉体電極に対する被処理歯車の位置制御が容易なものとなるので、上記のように被処理歯車の噛み合い始め側をラック状電極に接近させて、噛み合い始め側にのみ放電させるようになすことができ、これによってピッティングが発生しやすい歯車の噛み合い始め側のみに硬質被膜によるコーティングを施すことができ、この部分の耐ピッティング性を大幅に改善することができるようになるというさらに優れた効果がもたらされる。

【００１４】

【実施例】以下、本発明を実施例に基づいてさらに具体的に説明する。

【００１５】ＪＩＳ　Ｇ　４０５２に規定されるＳＣＭ４２０Ｈ鋼（クロムモリブデン鋼）を用いて、歯車形状に鍛造し、仕上げ加工したのち、常法に基づいて浸炭焼き入れ処理を施した。このようにして得られた被処理歯車Ｗ（ワーク）の歯面の表面硬度は、ビッカース硬さで、約８５０であった。

【００１６】一方、Ｔｉ合金粉末を用いて、図１（ａ）に示したようなラック形状の圧粉体電極Ｅを成形し、同図に示すように、放電液（白灯油）中において、浸炭焼き入れ処理を施した被処理歯車Ｗの噛み合い始め側のみを当該圧粉体電極Ｅに非接触で噛み合わせ、歯車Ｗを回転させると共に、圧粉体電極Ｅを移動させながら、これら電極Ｅと歯車Ｗとの間にパルス電圧を印加することによって放電させ、被処理歯車Ｗの噛み合い始め側にＴｉＣからなる硬質被膜を形成した。このとき、被処理歯車Ｗのコーティング部分における表面硬度については、ビッカース硬さで、約２５００であった。

【００１７】このようにして放電表面処理を施した歯車Ｗを実際のオートマチックトランスミッションに組み込んで耐久性試験を行い、当該歯車Ｗのピッティング寿命を調査し、硬質被膜の表面処理を行うことなく、浸炭焼き入れ処理のみを施した状態の比較例歯車の場合と比較した。

【００１８】この結果は、図２に示すとおりであって、浸炭焼き入れ処理のままの比較例歯車に較べて、ＴｉＣによる放電表面処理を施した発明例歯車のピッティング寿命が大幅に改善されていることが確認された。

【図面の簡単な説明】

【図１】（ａ）　本発明に係わる歯車の放電表面処理方法において、歯車の噛み合い始め側にのみ硬質被膜の表面処理を施す要領を説明する斜視図である。

（ｂ）　図１（ａ）に示したラック形電極の片側が消耗した後の表面処理要領を説明する斜視図である。

【図２】本発明に係わる放電表面処理を施した発明例歯車のピッティング寿命を放電表面処理が施されていない従来例歯車の場合と比較して示すグラフである。

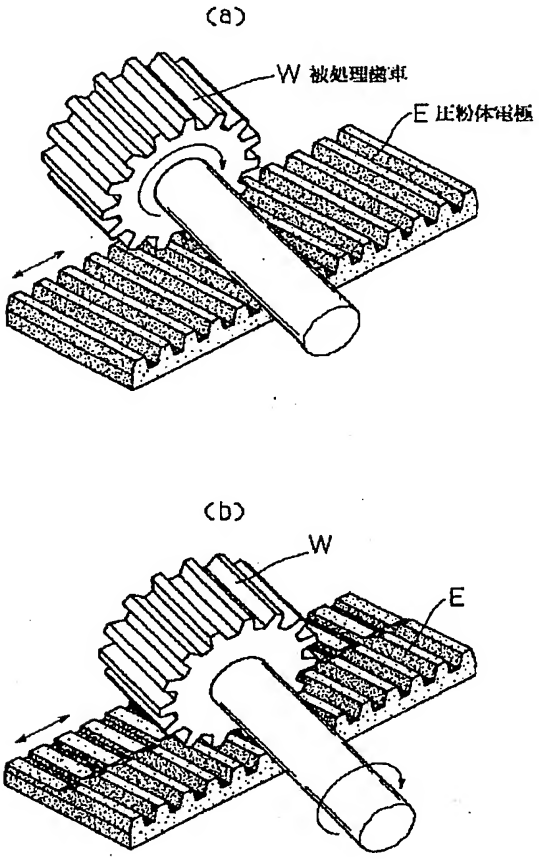
【図３】従来の歯車の放電表面処理方法を示す斜視図である。

【符号の説明】

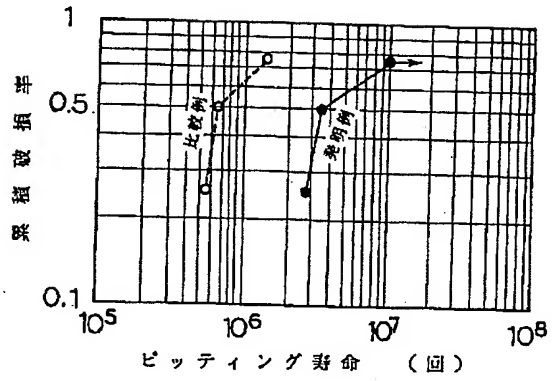
Ｅ　圧粉体電極

Ｗ　被処理歯車（ワーク）

【図１】



【図２】



【図３】